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EVALUATION OF 155MM M199 TUBE FORGING PRODUCERS

J. Passmore

July 1977

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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Two 155mm M199 howitzer tube forgings, produced by different vendors, were destructively tested to determine the quality of each vendor's forgings. Vendor A's forging did not meet military specifications in all cases; several RA values were below specification. Vendor B's forging was found to be acceptable, exceeding the requirements of the specifications in all cases.

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INTRODUCTION

The 155mm howitzer, M199, is one of the newest weapons to be manufactured at the Watervliet Arsenal. Full production of this tube will be starting shortly, and as a result of this planned production, vendors will be asked to submit bids for the furnishing of XM199 gun tube forgings.

An investigation to determine a vendor's ability to produce an acceptable tube forging was undertaken. To determine each vendor's ability to produce an acceptable tube forging, each prospective vendor was asked to supply one XM199 gun tube forging for qualification tests. These tests would determine if the vendor could meet the material requirements required by the specification and, also, would determine the uniformity of the material's properties.

Bids were requested from prospective vendors of gun tube forgings for the production of a single gun tube forging. Two vendors responded and each provided one tube forging for test purposes.

PROCEDURE

Each forging was sectioned along its length by taking test discs located perpendicular to the tube's axis. From each test disc, four (4) tensile and four (4) Charpy specimens were taken to determine the mechanical properties at that point in the tube. Two different specimen orientations

were tested, transverse and longitudinal, the longitudinal specimens being parallel to the axis or bore of the tube. Locations of the test discs and transverse specimens in each disc are shown in Figures 1 and 2.

Chemical analyses were performed upon the Charpy specimens exhibiting the lowest impact strength for each transverse disc to determine if there were any significant segregation. Metallography was also performed on random pieces of material obtained from each forging to determine the microstructure of that forging.

RESULTS AND DISCUSSION

The results of the mechanical tests, the vendors' test data, and the chemical analyses are tabulated in Tables 1 - 3. A graphical presentation of the results for the mechanical tests are given in Figures 3-6. Each graph presents the minimum and/or maximum values as determined by the appropriate specification[1], the mechanical properties found as a result of testing each vendor's forging, and the physical location of the disc in the tube. Mechanical properties are graphically presented for three (3) values only, the highest value, the average value, and the lowest value from each disc.

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1. MIL-S-46119A(MR) dated 7 March 1973.

For Vendor A, the average transverse yield strength at the breech end of the tube was 172.6 ksi and progressively decreased to an average yield strength of 169.3 ksi at the muzzle end. The largest variance within a specific disc was 6 ksi for Disc H. The transverse reduction in area (%RA) varied from a disc averaging 42.8% to a disc averaging only 27.0% for a variance of 15.8% along the length of the tube with no pattern attributed to the position in the tube forging. Even within one disc, Disc C, %RA varied 22.6% between specimens. Three (3) of the twenty-four (24) transverse specimens did not meet the military requirement of 25% RA minimum. The minimum value was 23.2%. Impact properties of the tube were fairly uniform along the length of the tube with the lowest value being a marginal 16.8 ft-lb and the highest value being 23.4 ft-lb. Based upon a sample of this vendor's records of current M185 gun tube forging production, the marginal impact strengths and low RA's were found to be not unusual occurrences.

For Vendor B, the average transverse yield strength varied from a low of 171.4 ksi to a high of 176.9 ksi with the largest variance within a single disc being 6 ksi for Disc F. The average %RA of the gun tube showed excellent uniformity along the tube's length, with a spread

of only 4.2% in average RA. The largest variation within a single disc was 7.5% for Disc J. Average transverse impact properties were consistently above 26 ft-lb with a high average of 33.9 ft-lb for Disc D.

Vendor A's data showed good agreement with the test results except for the impact properties, where 50% of the test results were lower than the lowest impact strength reported by this vendor. Vendor B's data showed excellent agreement with the test data for all properties.

The chemical analyses taken from each tube were uniform along the length of both forgings. Both vendors' forgings showed a microstructure consisting of tempered martensite, Figures 7 and 8.

CONCLUSIONS

Vendor A's forging had good yield strengths, marginal impact strengths, and %RA's which varied widely with location in the forging. Three (3) of the twenty-four (24) %RA's did not meet the minimum requirements set by military specifications. The marginal impact strengths and low %RA's were found to be not unusual occurrences for this vendor.

Vendor B's forgings had, on an average, higher yield strengths, impact strengths, and %RA's than Vendor A's forging. Not only were Vendor B's RA's higher than Vendor A's RA's, but they were more uniform. As a result of tests,

Vendor B's M199 forging met the appropriate military specifications in all cases.

While these tests were not meant to approve or disapprove a vendor, they do indicate that Vendor B is capable of producing a high quality tube, while Vendor A shows a potential for supplying tubes with lower ductility than required.

TABLE 1. MECHANICAL PROPERTIES - VENDOR A

DISC LOCATION	0.1% YS (KSI)	RA (%)	CVN (FT-LB)
Requirement	160/180	25	15
A	169.6	35.4	21.2
	169.3	33.6	19.3
	168.7	31.4	17.0
B*	169.3	63.2	37.8
	168.3	61.5	36.7
	167.8	60.4	34.8
C	170.2	40.3	21.3
	169.0	30.6	19.0
	167.8	23.7	17.6
D	171.7	46.2	23.4
	170.3	42.8	22.3
	168.4	37.7	21.3
E*	170.8	61.6	38.0
	169.4	60.3	37.7
	167.8	58.3	37.3
F	172.9	38.5	19.5
	171.3	33.4	18.9
	170.8	26.6	17.7
G	173.8	31.8	21.0
	173.0	27.0	19.9
	171.7	23.2	18.7
H*	172.0	63.2	37.0
	169.7	61.3	35.6
	166.0	58.7	33.7
J	173.8	35.8	19.0
	172.6	30.6	17.8
	170.8	23.7	16.8

TABLE 1. MECHANICAL PROPERTIES - VENDOR A (cont)

DISC LOCATION	0.1% YS (KSI)	RA (%)	CVN (FT-LB)
Requirement	160/180	25	15
Vendor (Breech)	170.5	35.0	33.0
	168.9	32.5	25.4
	168.1	27.5	22.0
Vendor (Muzzle)	172.1	32.8	21.0
	170.1	28.6	20.2
	168.5	25.4	19.5

*Denotes longitudinal specimens

NOTE: Values given represent high, average, and low values for each disc.

TABLE 2. MECHANICAL PROPERTIES - VENDOR B

DISC LOCATION	0.1% YS (KSI)	RA (%)	CVN (FT-LB)
Requirement	160/180	25	15
A	176.5	45.4	28.0
	175.6	42.1	26.2
	174.8	39.8	24.8
B*	176.5	60.0	42.3
	175.5	58.0	39.7
	174.1	57.2	33.6
C	172.0	47.8	31.6
	171.4	43.7	31.0
	170.8	41.2	30.0
D	174.7	47.0	36.0
	174.3	44.4	33.9
	173.2	41.6	32.7
E*	176.2	59.2	43.5
	174.5	58.3	42.3
	171.7	57.5	41.8
F	178.0	43.6	32.0
	175.9	41.9	29.6
	172.0	40.3	28.0
G	177.1	48.3	31.2
	176.9	46.1	30.5
	176.8	43.6	30.0
H*	174.7	61.6	45.0
	174.0	60.4	43.4
	173.2	58.3	42.0
J	176.8	47.8	27.5
	175.0	43.2	27.0
	173.2	40.3	26.3

TABLE 2. MECHANICAL PROPERTIES - VENDOR B (cont)

DISC LOCATION	0.1% YS (KSI)	RA (%)	CVN (FT-LB)
Requirement	160/180	25	15
Vendor	173.0	46.5	29.5
(Breech)	171.9	44.2	28.7
	170.5	40.7	28.0
Vendor	172.2	45.7	29.5
(Muzzle)	171.7	45.5	28.6
	170.5	45.3	27.0

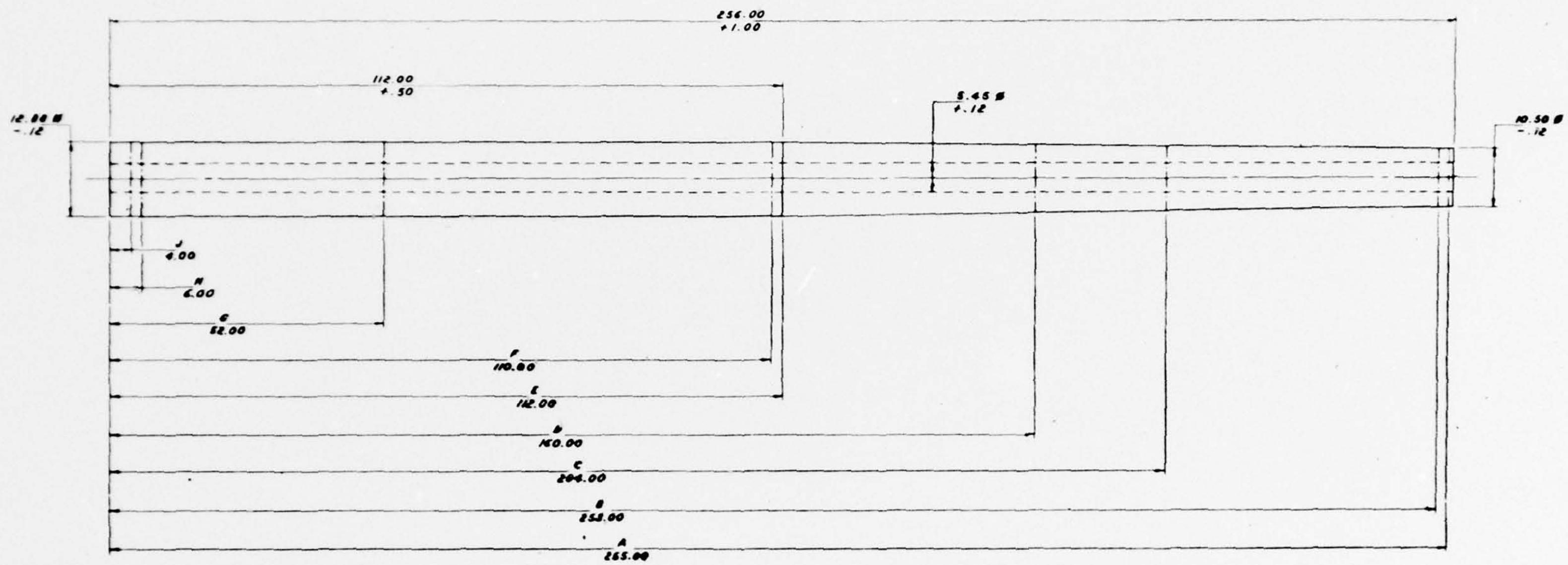
*Denotes longitudinal specimens

NOTE: Values given represent high, average, and low values for each disc.

TABLE 3. CHEMICAL ANALYSES*

	C	Mn	P	S	Si	Ni	Cr	Mo	V
Vendor A	.34	.47	.013	.004	.11	2.94	1.01	.44	.09
Disc A	.34	.51	.006	.008	.12	2.96	1.01	.46	.09
C	.33	.55	.005	.005	.13	2.72	1.01	.46	.09
D	.33	.51	.006	.006	.12	2.82	1.01	.46	.09
F	.34	.50	.006	.012	.12	2.85	1.01	.46	.09
G	.34	.52	.010	.014	.12	2.85	1.01	.46	.09
J	.33	.51	.007	.008	.12	2.87	1.01	.46	.09
Vendor B	.32	.59	.008	.007	.19	2.43	.97	.54	.13
Disc A	.34	.67	.007	.008	.25	2.43	.99	.60	.13
C	.31	.67	.008	.007	.25	2.48	1.00	.60	.13
D	.31	.67	.007	.004	.25	2.51	1.00	.60	.13
F	.32	.63	.007	.007	.24	2.50	1.00	.59	.13
G	.32	.65	.007	.004	.24	2.47	.99	.58	.13
J	.34	.65	.007	.006	.25	2.53	1.00	.60	.13

*NOTE: All values are expressed in weight percent.



NOTE:
1. LOCATIONS B, E & H ARE LONGITUDINAL SPECIMENS

Figure 1. Location of test discs.

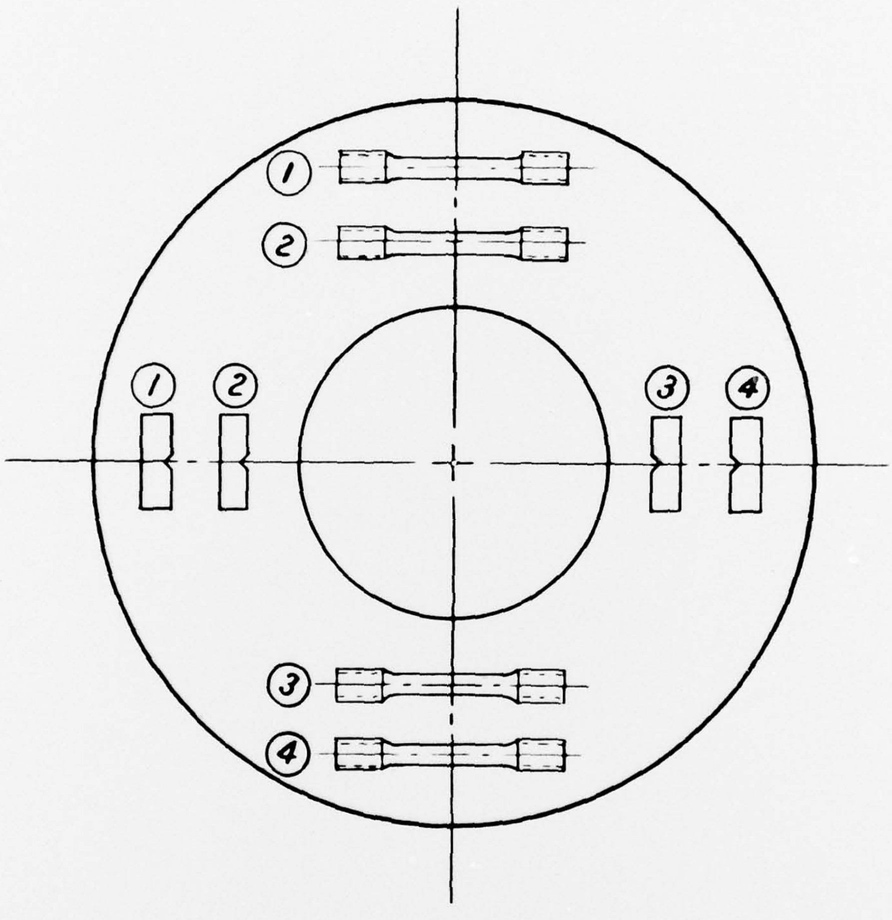


Figure 2. Location of transverse specimens.

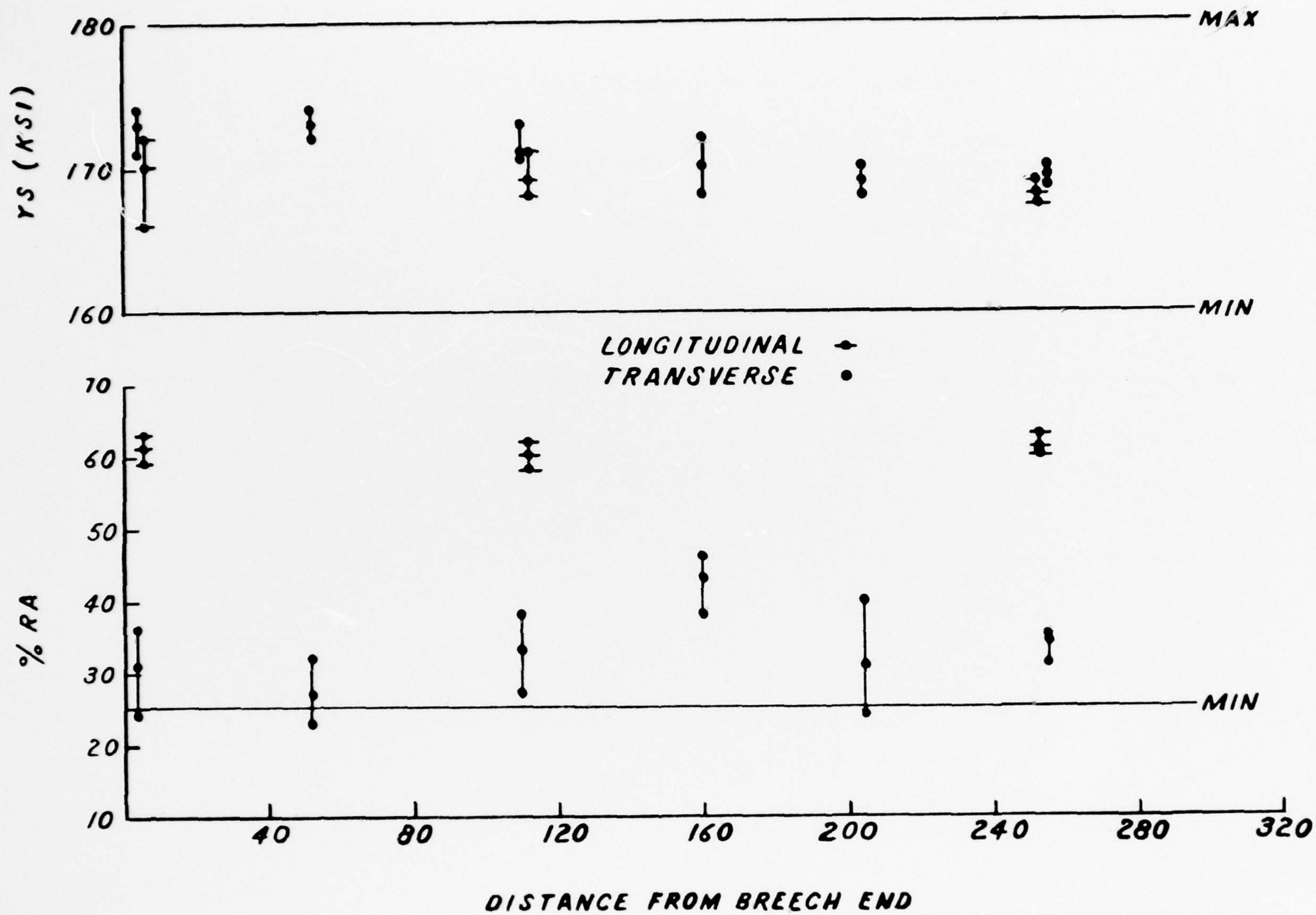


Figure 3. Mechanical properties - Vendor A

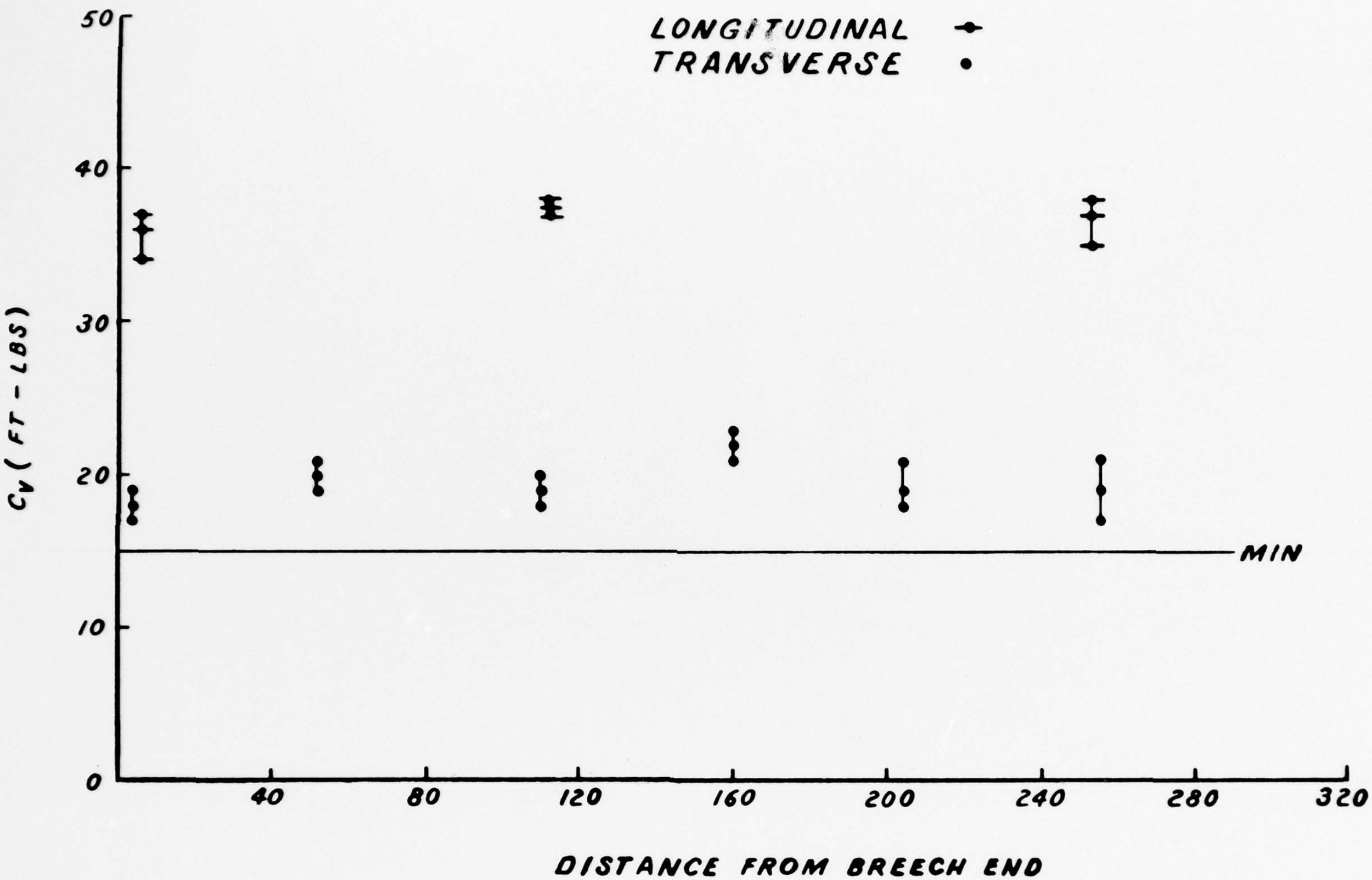


Figure 4. Mechanical properties - Vendor A

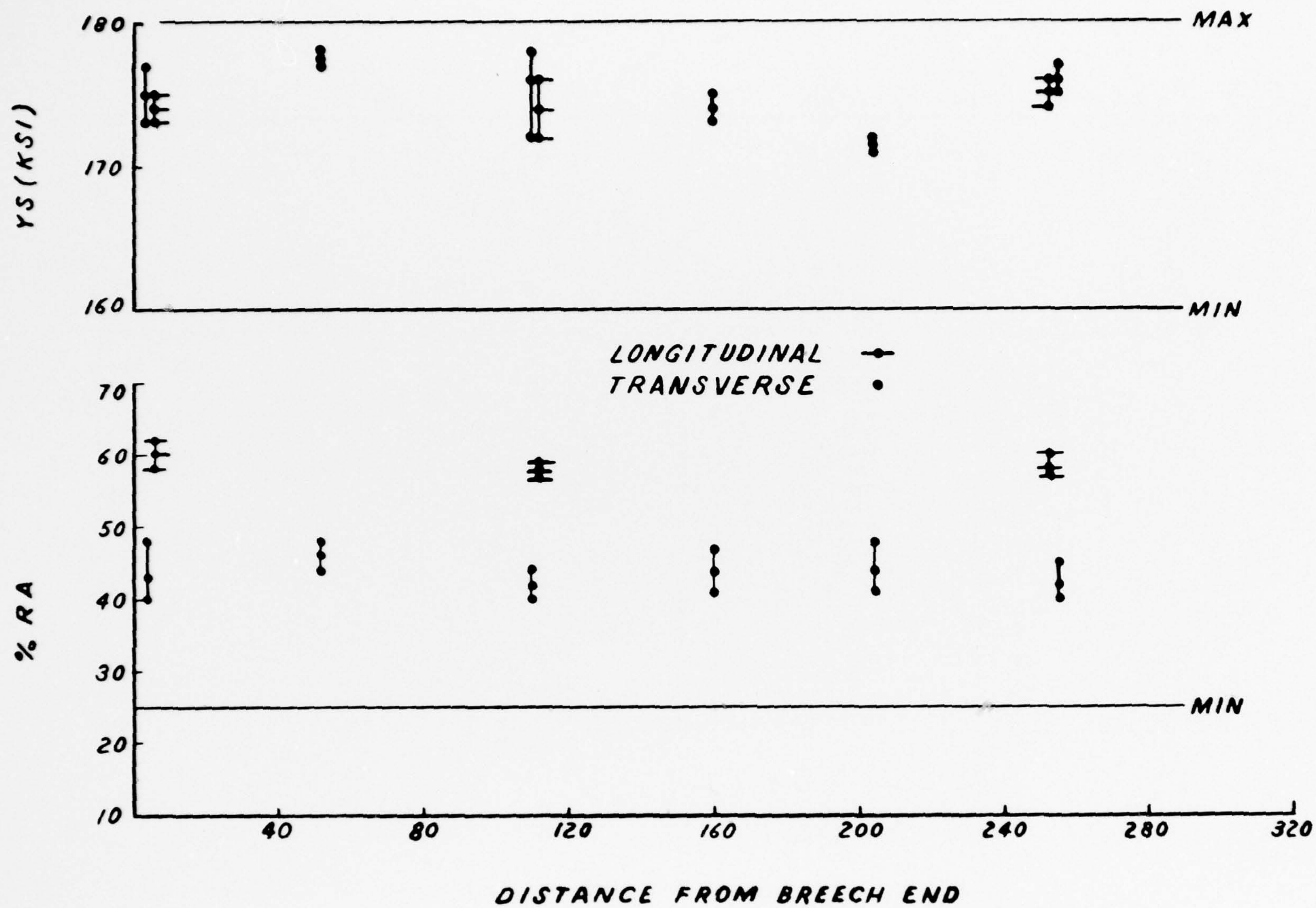


Figure 5. Mechanical properties - Vendor B

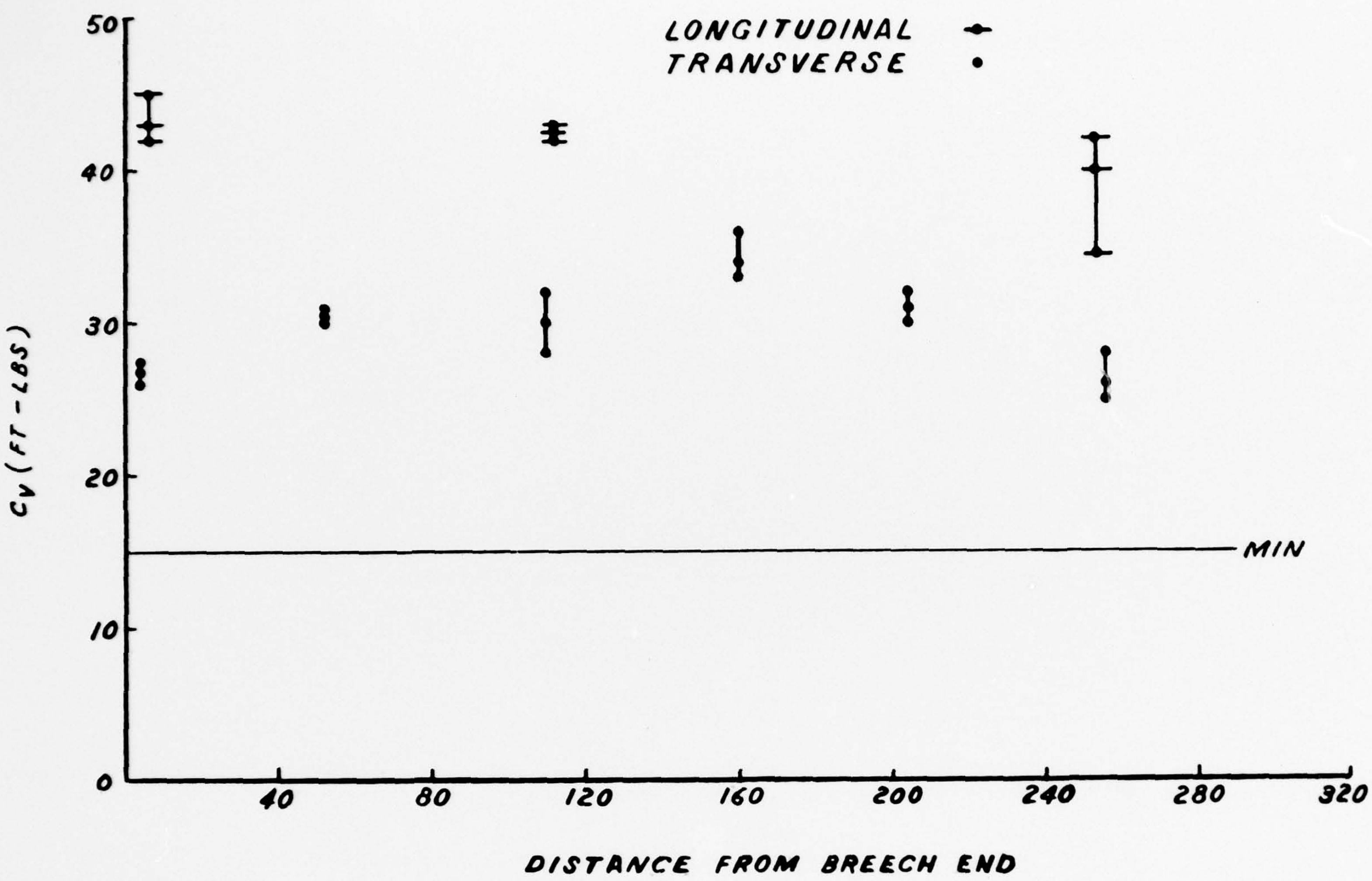
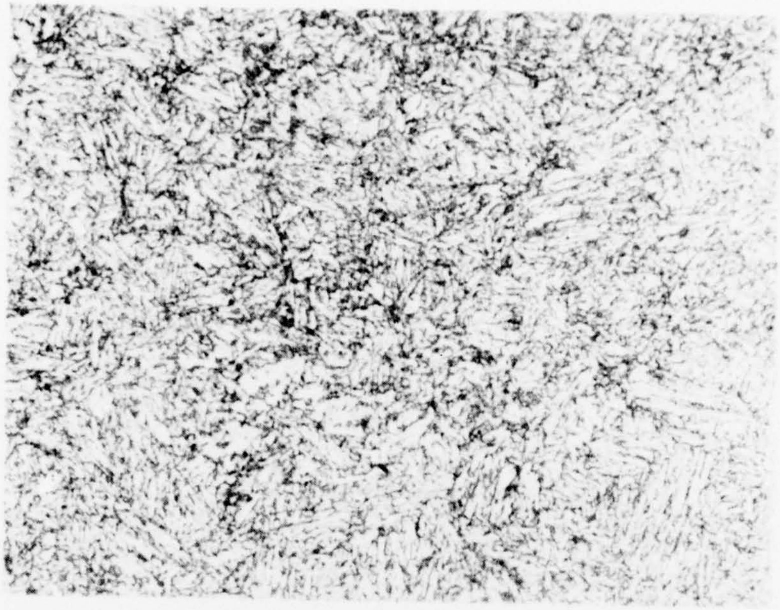
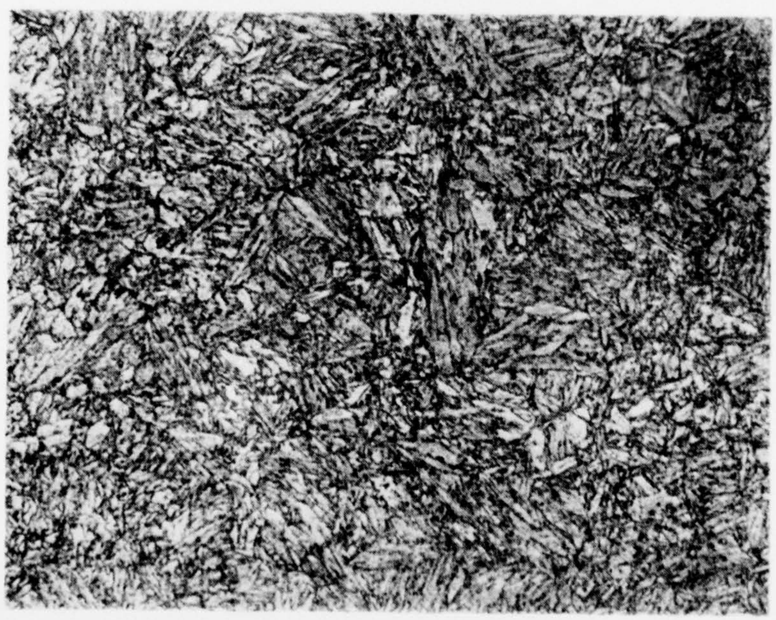


Figure 6. Mechanical properties - Vendor B



Vendor A



Vendor B

Figure 7. Typical microstructure - tempered martensite (magnification - 1000X).

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